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To: Mr. R. Wilson
Director
Health and Safety Division
H2A27

VDU SHIELDING

S.M. Harvey

Health problems associated with Video Display Unit (VDU) operation are often attributed to the presence of "radiation". In consequence, it is thought that shielding will make the units safe. Some of the VDU-shielding solutions being proposed are faulty in conception or design and will do little more than create a subjective sense of security.

1. INTRODUCTION

Video display units (VDUs) are designed to provide a visual display of information. The display is produced by periodically scanning an intensity modulated electron beam down and across a phosphor coating on the inside of a cathode ray tube (CRT). The electron beam is accelerated towards the CRT face and deflected in the vertical and horizontal directions by internal fields produced by steady-state or fluctuating voltages and currents within the unit.

These short-range electric and magnetic fields extend into the workspace immediately surrounding the unit. Although the fields at normal working distances are very low, this so-called "radiation" has become associated in the public conciousness with health related problems reported by VDU operators. Health risks from VDU "radiation" have been discounted by almost all reputable health and safety agencies. Nevertheless, there is considerable pressure for some form of electromagnetic shielding of VDUs.

As a result, shielding devices or modifications that are claimed to have health benefits are being promoted and may be required by pending legislation in some jurisdictions. Some of these shielding devices and techniques are evaluated briefly in this report.

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2. VDU FIELDS

Shielding devices need to be evaluated with reference to the fields actually produced by a VDU. There are four fields of possible biological interest. The fields and sources described below are representative of most units.

1. 60-Hz Modulated Electrostatic Field: This field is produced by the charge on the face of the CRT and is largely confined to the front of the unit. The field is highly variable, being affected by humidity, capacitance between the CRT and external objects, and touching the CRT, to name a few factors. It can range from positive to negative values.

2. RF Electric Field: This field is produced by a high-voltage pulse forming circuit that generates the beam accelerating voltage. The pulse repetition rate is in the range from 16 to 18 kHz for most units. Because of the location of the circuit, the field on some units is highest near the back of the case.

3. 60-Hz Magnetic Field: This field is produced mainly by the current through the vertical deflection coil and is nearly symmetrical around the coil. There is also some contribution from the power transformer.

4. RF Magnetic Field: This field is produced mainly by the current through the horizontal deflection coil and is nearly symmetrical around the coil. The frequency is the same as that of the rf electric field. There is also some contribution from the primary winding of the flyback transformer.

It is frequently assumed that the flyback transformer is the principal source of the radiofrequency fields. In fact, this component appears to be a minor contributor. As noted above, the rf magnetic field is produced mainly by the horizontal deflection coil. The highest rf electric fields appear to be produced by a circuit conductor, up to 10 or 15 cm long, that is used on some units to connect the flyback transformer to a remotely-mounted diode rectifier.

3. FIELD MITIGATION TECHNIQUES

Electric and magnetic fields outside the case of the VDU can be reduced by several techniques. Some manufacturers appear to have produced low-field units, without shielding, through careful circuit design. Shielding may be applied to any unit but is evidently more relevant to those units that produce higher fields.

The presence of shielding in a unit does not guarantee low field levels. At low frequencies, electric and magnetic shielding techniques are different. A good magnetic shield will, if grounded, also shield electric fields but the converse is not necessarily true. A shield that is not correctly placed relative to the

source of the field and the position of the operator will not be effective. Proper mitigation techniques should therefore include the following three steps:

(a) Use good initial circuit design,

(b) If further field reduction is required, install shielding that is correctly engineered to achieve specific field reductions,

(c) Test to ensure that the design objectives are met.

4. SHIELDING DEVICES

Because of the various circuit components contributing to the electric and magnetic fields, an overall case shield is probably the preferred solution. If the shield is installed for safety reasons, it should be effective for all of the identified fields since there is no a priori reason to assign a greater risk to any one in preference to the others. Some proposed shielding solutions are evaluated in this context.

A) The Conductive Screen Cover, or Electrostatic Screen: Electrostatic screens are intended to reduce the modulated electrostatic field in front of the CRT. They have little if any effect on other fields. The screen may be installed as a conductive surface on the CRT or as an after-market device that also functions as an anti-glare or anti-reflection filter. Two after-market devices designed to mount on the front of the VDU case were tested.

The first device was grounded by a wire that connected to a nearby receptacle. Product literature claimed that the screen would "neutralize 99% of the ions propelled from the tube's surface". Some similar screens are claimed to completely eliminate the electrostatic field. This device was found to reduce the electrostatic field at the operator's position by a factor of 40:1. With such a reduction, the electrostatic fields are substantially lower than natural fields including those produced by the human body itself.

The ion-neutralization claim could not be tested as the total ion current between a highly-charged VDU and a grounded surface in the laboratory was too small to be measured ($<10^{-12}$ A). It is concluded that this claim is probably not relevant to human health.

The second device was not provided with a ground connection. Product literature claimed an 80 to 90% reduction in electrostatic field based on tests performed at the Danish Technical University in Copenhagen. This device was found to have no measurable effect on the electrostatic field. The Danish tests appear to have been performed with improper test procedure (see Appendix).

B) The Box Shield: Box shielding in the present context is defined to be a shield that covers the top, back and sides of the VDU. Such shields may be installed during manufacture through the use of conductive plastic, paint, plating

or foil. However, external boxes lined with metal foil are being manufactured, and sold, for after-market purposes. Box shields of this type can reduce the radio-frequency electric field near the back of some units by a factor of 20:1 or more. However, they have little, if any, effect on the other fields. The effect on the rf electric field at the operator's position, factors between 0 and 6:1 having been reported, is minimal.

Box shields will therefore have a significant effect on human exposure only if: (a) a VDU produces strong rf electric fields at the back or sides of the unit, and (b) personnel normally work close to the back or sides. Since the rf electric field is usually the energetically weakest of the VDU fields, the effect of the box shield on the electromagnetic environment will in any event be small.

C) The Flyback transformer Shield: A shielding solution frequent proposed in the literature is the flyback transformer shield. Whether the shielding should be for electric or magnetic fields is not specified. As noted previously, the flyback transformer is not generally the principal source of either the electric or the magnetic fields except perhaps on those units whose circuits have already been designed for low fields. Paradoxically, therefore, a shield placed around the transformer will be least effective on the units having the highest fields, contrary to the intended purpose.

5. CONCLUSIONS

Health related problems reported by VDU operators are sometimes associated with the presence of electric and magnetic fields close to the units. In consequence, there is considerable pressure to reduce the fields, usually by some form of shielding, in order to make the units "safe".

The fields produced by VDUs can be maintained at very low levels by good circuit design, by shielding, or by a combination of the two. In order to ensure a field-free environment for VDU operators, it is necessary to account for four different fields originating with several sources within the unit. Removal of only one field will have, at best, only a 25% probability of making a unit "safe" based on present knowledge (or lack of knowledge) about field hazards. Most shielding solutions currently being proposed affect only one or the other of two electric fields. Some of these solutions are faulty in conception or design and will do little more that create a subjective sense of security. If shielding is to be used on VDUs, it should be designed and tested according to proper engineering criteria.

Approved:

A.F. Baljet
Manager
Electrical Research Department

Submitted:

S.M. Harvey
Engineer/Physicist
Science Section
Electrical Research Department

SMH:CB

APPENDIX

Method for Measuring the Shielding Effectiveness of Electrostatic Screens

The method often used for measuring the effectiveness of electromagnetic shields is as follows:

(a) Turn on the source and measure the field strength.

(b) Place the shield between the source and the measurement apparatus.

(c) Repeat the field strength measurement.

This method, if used for testing the effectiveness of electrostatic screens installed on video display units, will yield incorrect results. Four possible sources of error have been identified, although there may be others.

First, the VDU electrostatic field drifts with time. It can change by up to 50% within a half hour of turn-on.

Second, the installation procedure may leave an induced charge trapped on the screen if it is ungrounded. The induced charge creates a cancelling electrostatic field that is not present in normal operation.

Third, if the CRT is touched during the installation procedure, the charge normally resident on the CRT may be removed.

Fourth, Installation of the screen changes the capacitance between the CRT and ground. According to the well-known relation Q=CV, a sudden increase in capacitance will result in a corresponding reduction in CRT voltage and therefore also in the source electrostatic field. The voltage may take hours to recover.

The test procedure outlined below was developed to eliminate these sources of error.

1. Place VDU in test location. Do not install electrostatic screen. Plug unit in but do not turn on. Allow 24 hours for unit to equilibrate with ambient temperature and humidity. Maintain the same ambient conditions throughout test.

2. Turn unit on and monitor variations in electrostatic field for a period of 2 to 3 hours. If a display is used on the CRT follow identical set-up procedure for all tests. Record field values in graphical form. Do not touch the face of the CRT.

3. Turn unit off and install electrostatic screen per manufacturer's instructions. Leave unit to re-equilibrate for 21 to 22 hours (ie allow 24 hours between tests. Ten to twelve hours might be sufficient but would require shift work).

4. Turn unit on and monitor variations in electrostatic field for a period of two to three hours. Follow procedure identical to that of step 2. Do not touch the screen or the face of the CRT.

5. Turn unit off and remove electrostatic screen. Leave unit to re-equilibrate for 21 to 22 hours as in step 3.

6. Repeat steps 2 to 5 several times in order to determine the amount of statistical variation of the data.

7. Compare graphs obtained with screen absent with those obtained with screen installed. The quantitative differences represent the "shielding effectiveness" of the screen.

Note: Electrostatic fields should be measured with the VDU operator or a simulated operator in position in order to establish the correct capacitive coupling conditions.